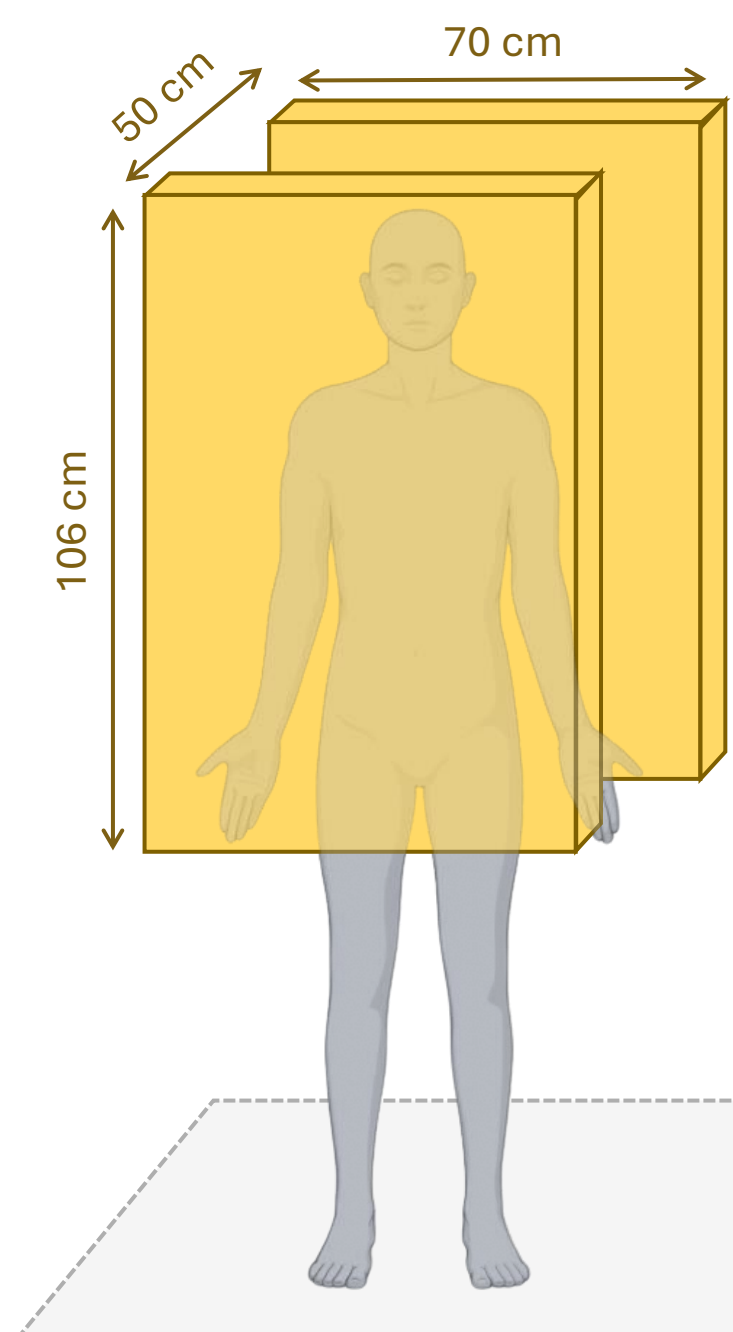


Deep learning based sinogram inpainting of sparse-view (rectangular) CT data

Walk-Through PET [1]

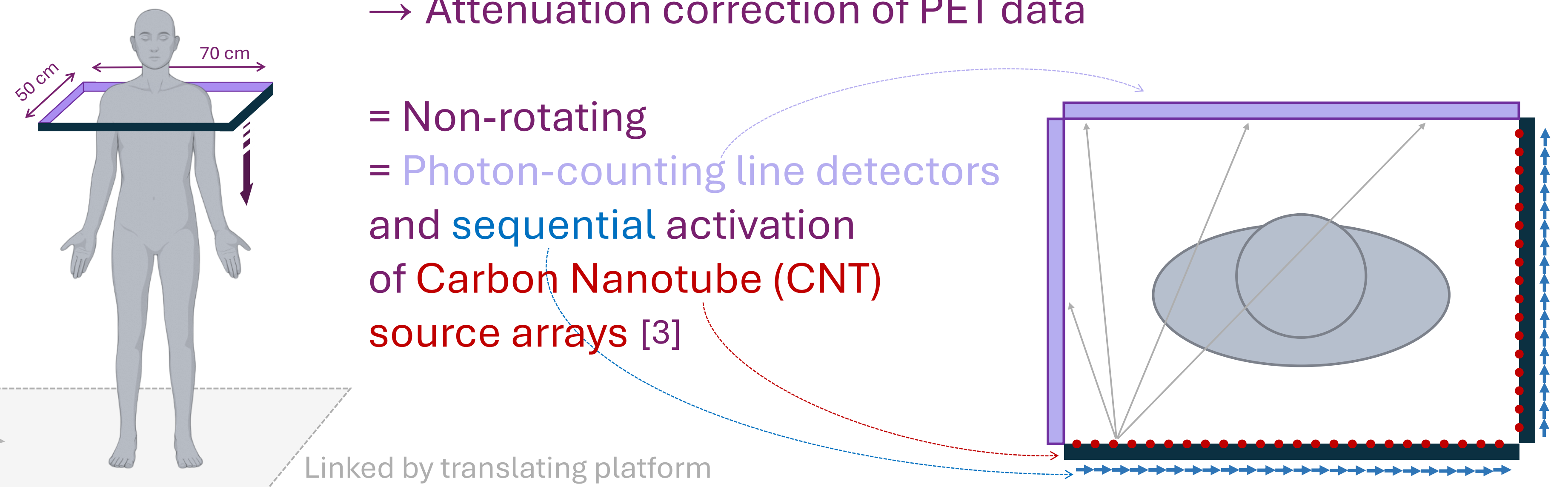
- = WT-PET
- = Long axial field-of-view
- = Two flat panels with monolithic detectors
- + Reduced cost
- + Reduced scan time
- + Reduced dose
- + Improved resolution
- + Increased throughput



Rectangular CT [2]

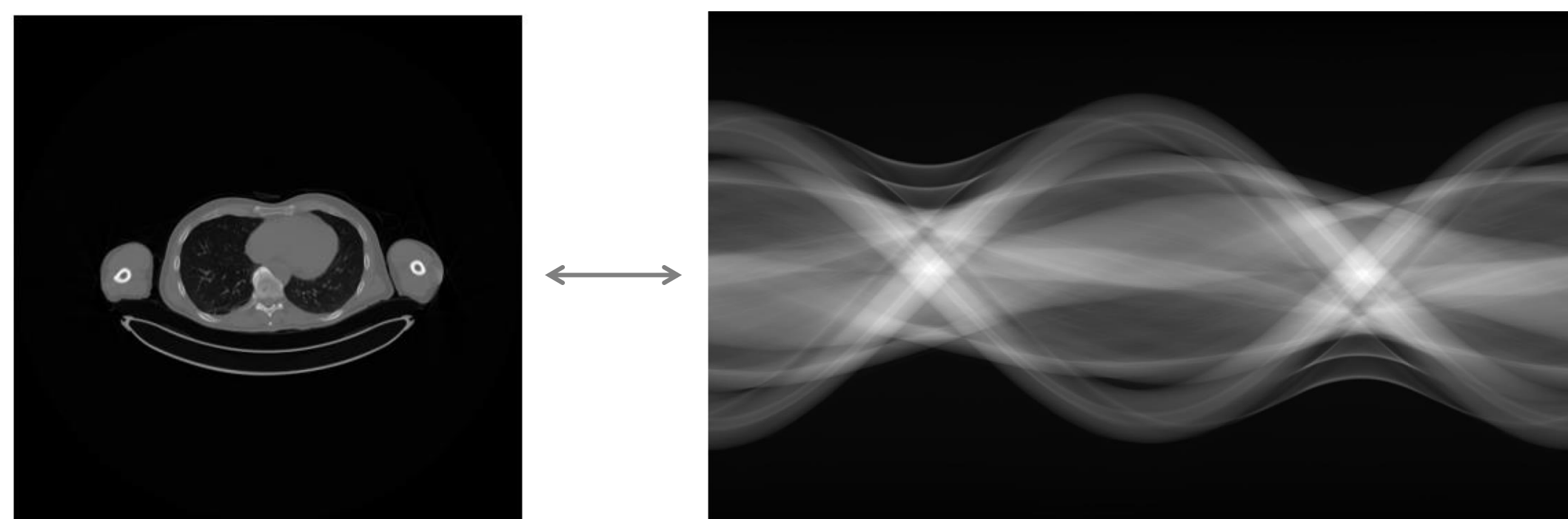
- Anatomical co-localization
- Attenuation correction of PET data

- = Non-rotating
- = Photon-counting line detectors and sequential activation of Carbon Nanotube (CNT) source arrays [3]



Cylindrical CT data

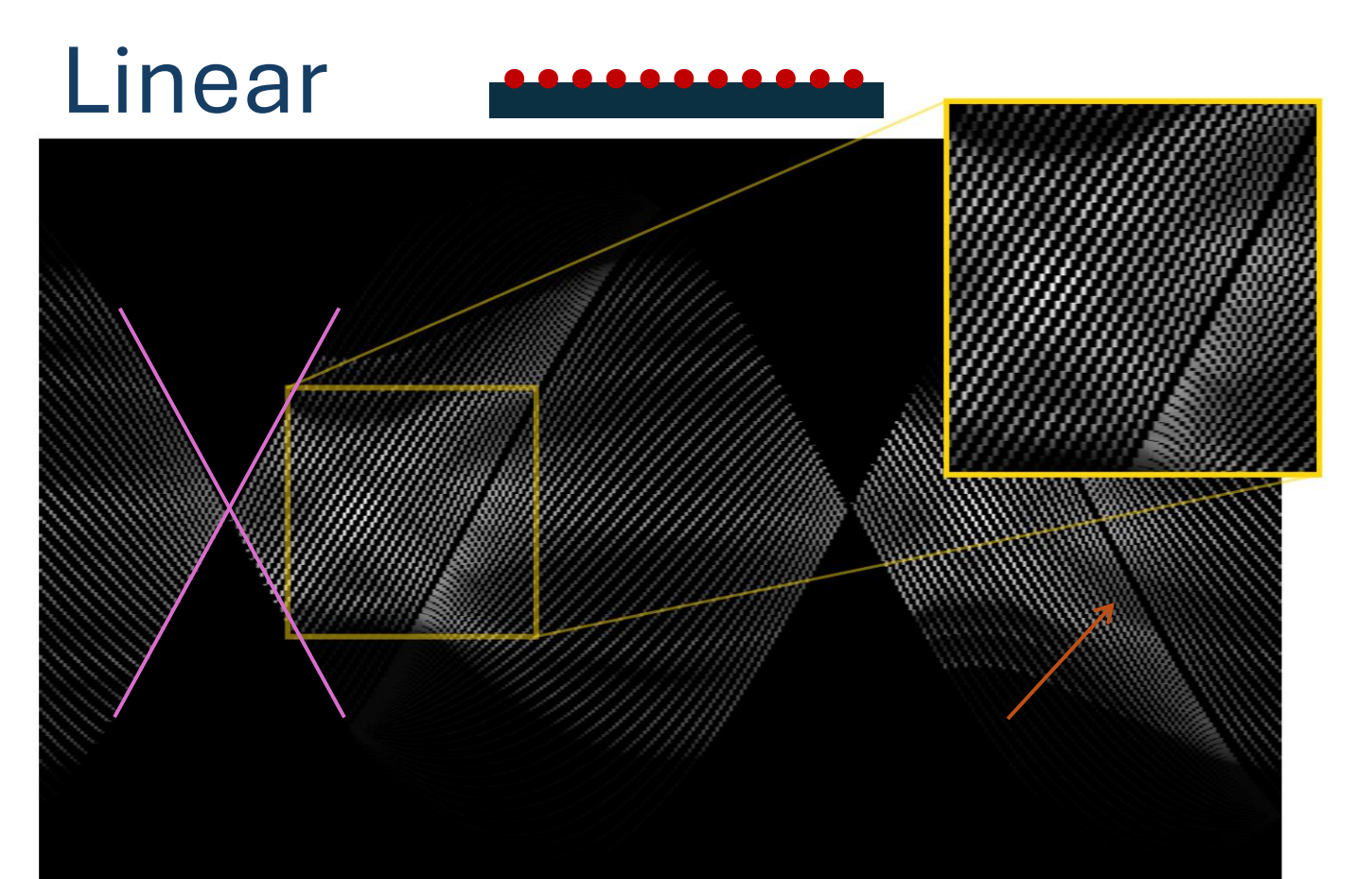
- = SOTA Quadra CT
- = Rotating scan mode
- = Full sinogram
- = 360° rotation



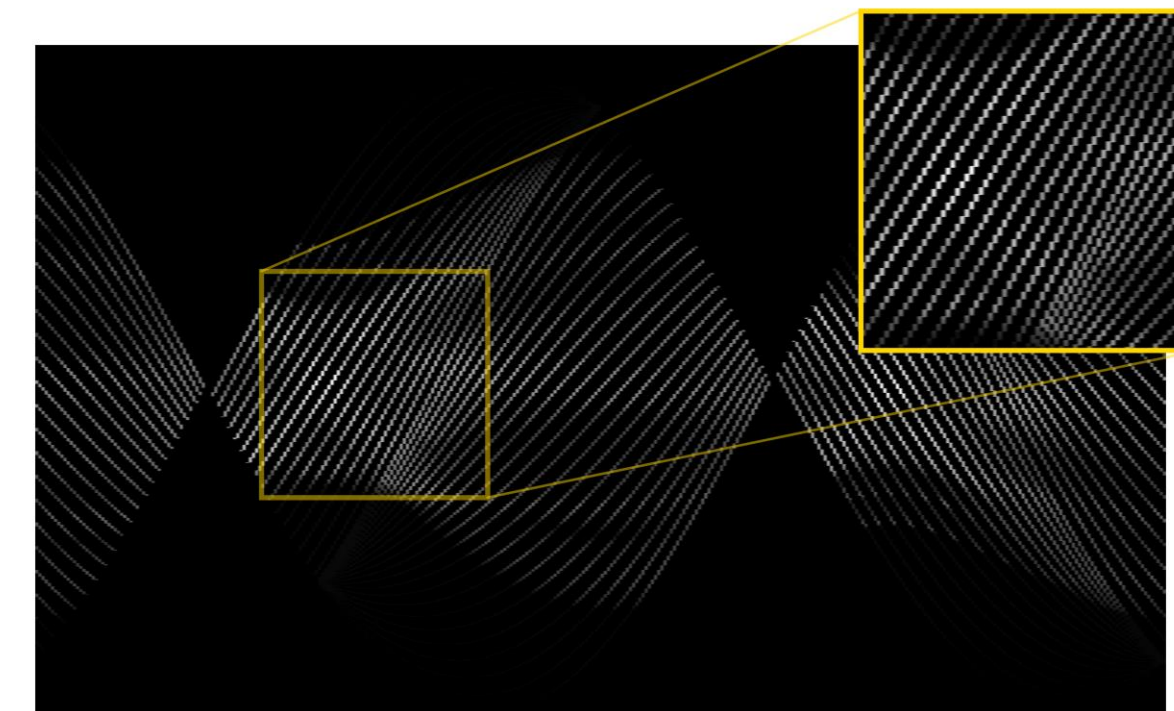
Sparse Rectangular CT data

- ~ Dependent on source placement

- Triangular gaps due to geometry
- Diagonal gaps due to corner margin
- Sparsity due to source placement

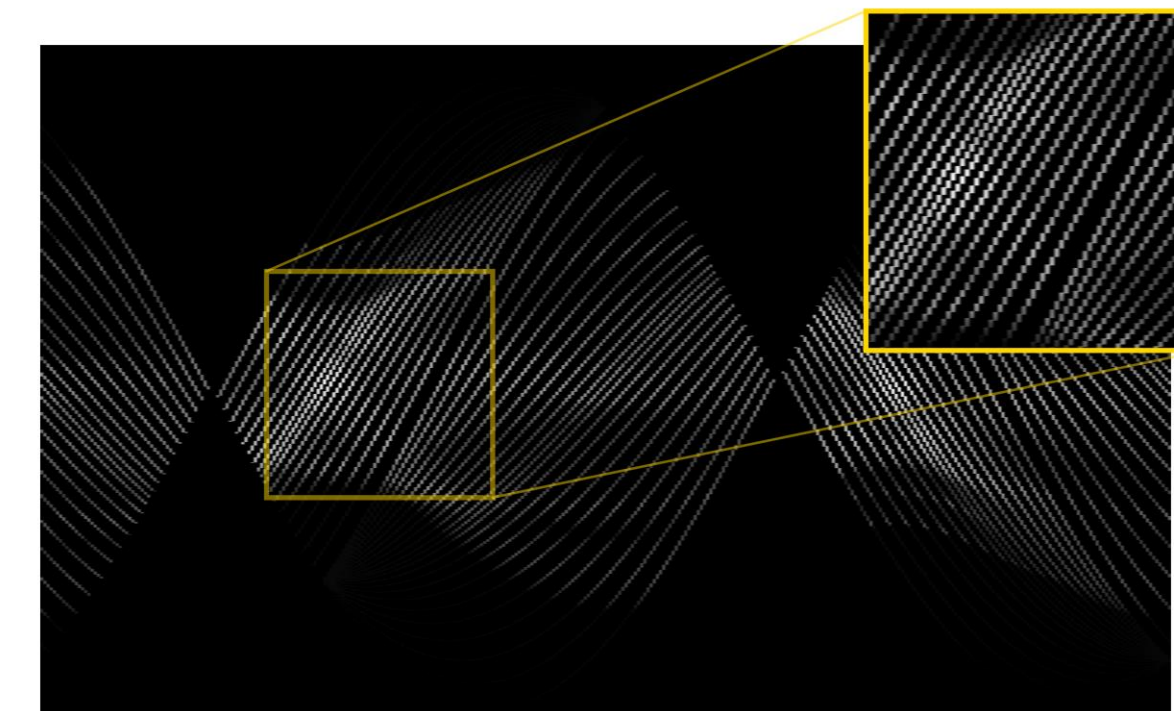


Sparse



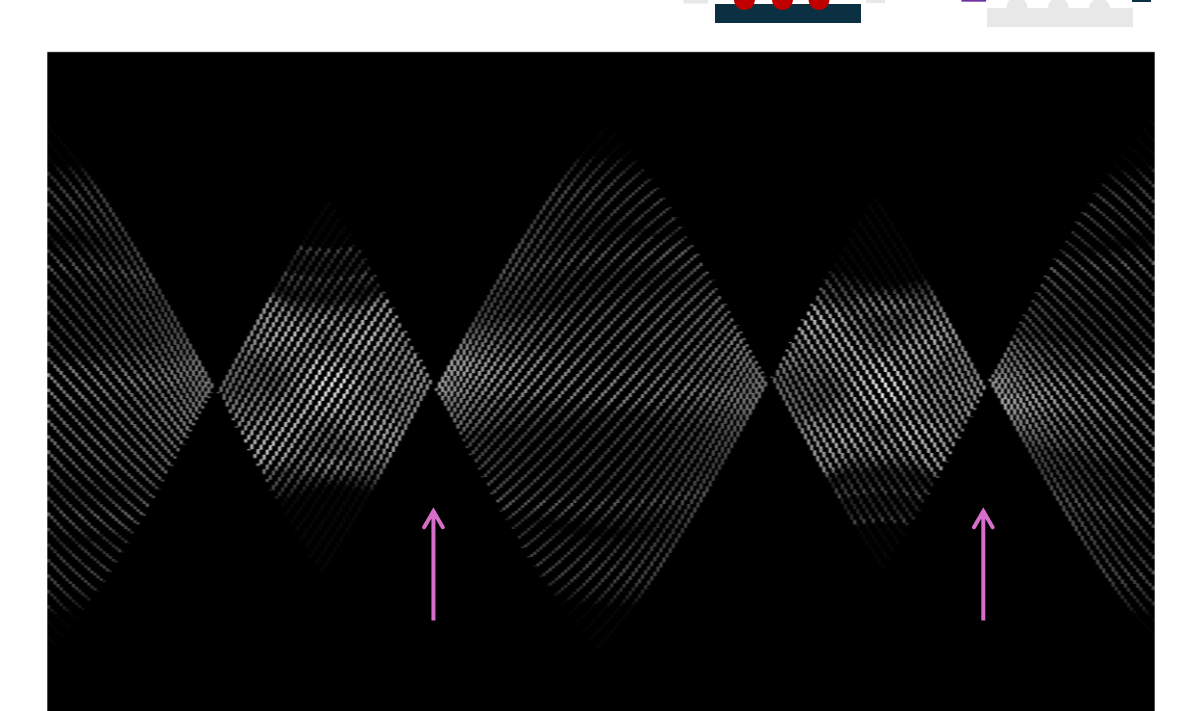
+ reduce cost

Non-linear



+ efficient use

Opposite



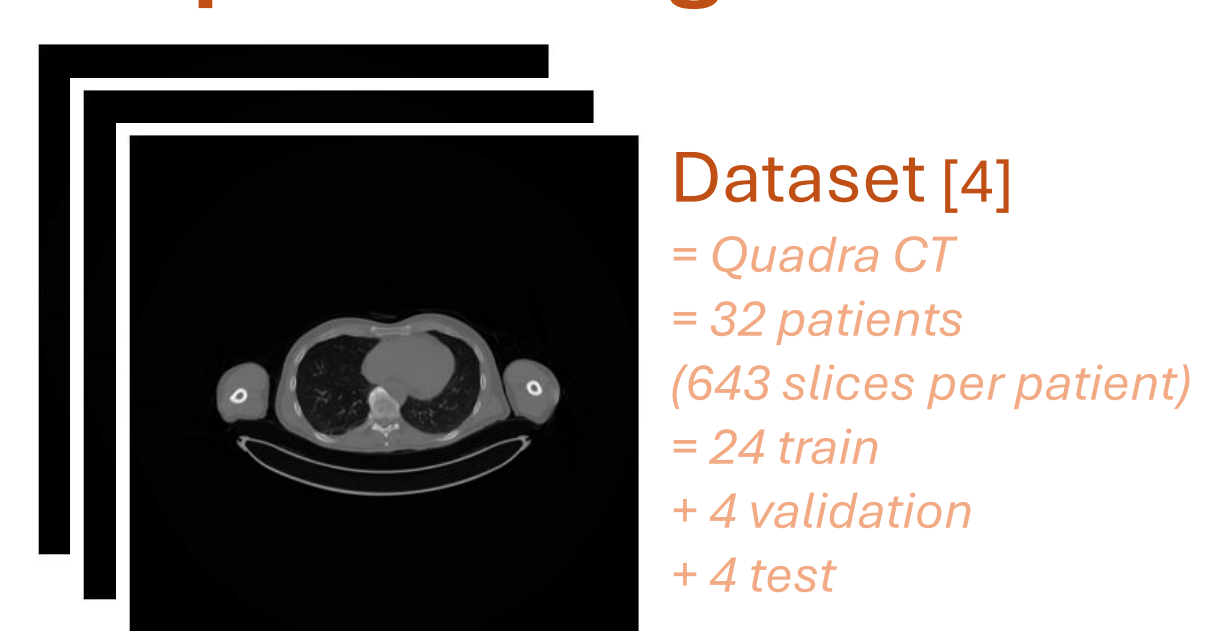
+ faster scan

Aim

→ Develop a deep learning approach for sinogram inpainting, enabling a cost-effective rectangular CT to complement the WT-PET

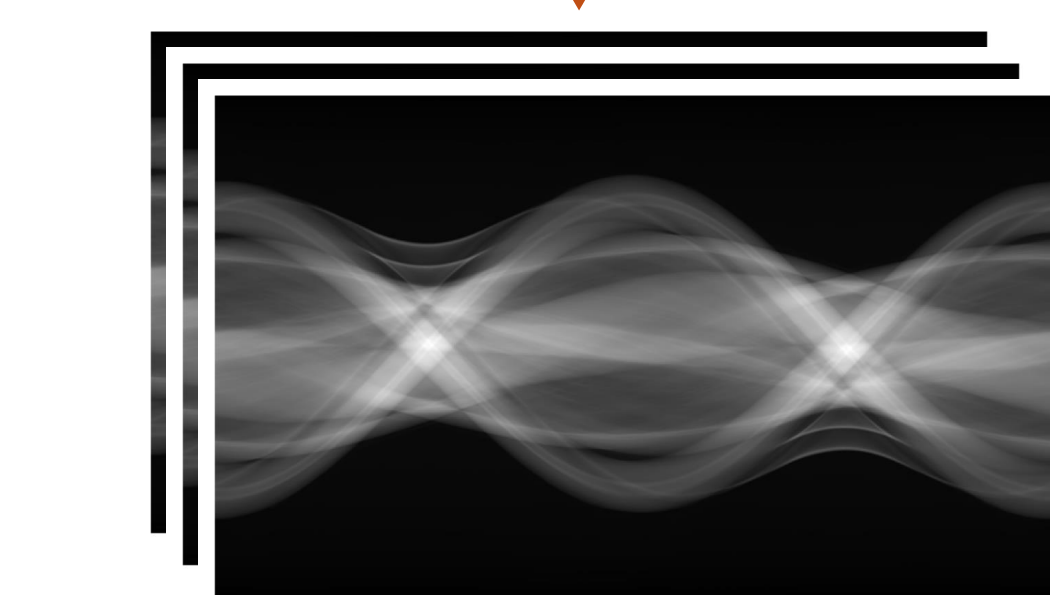
Deep learning based inpainting

Preprocessing

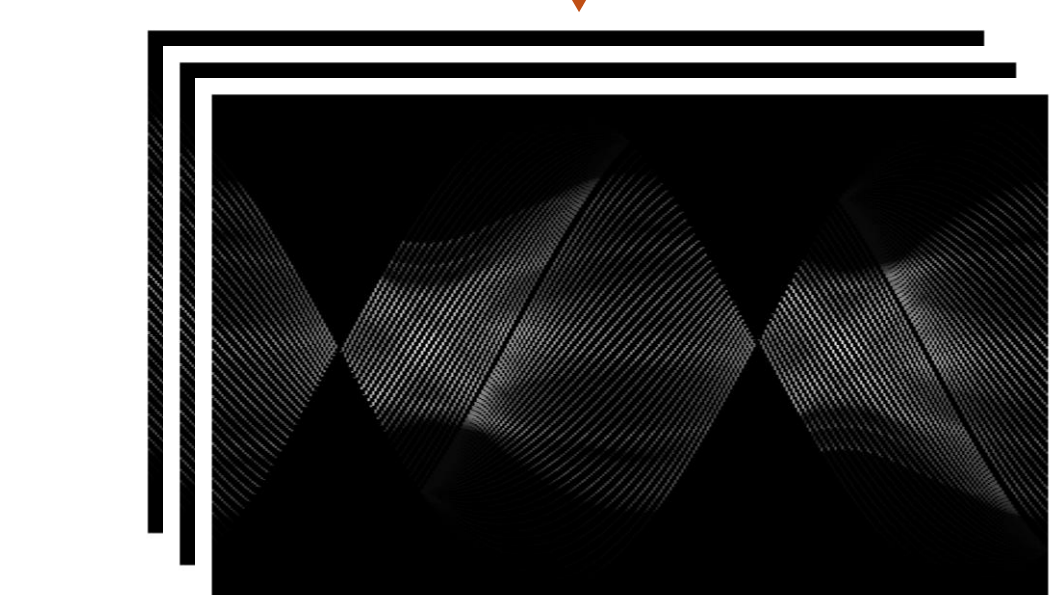


- Dataset [4]
- = Quadra CT
- = 32 patients (643 slices per patient)
- = 24 train
- + 4 validation
- + 4 test

Forward projection
Obtain full sinogram (GT)

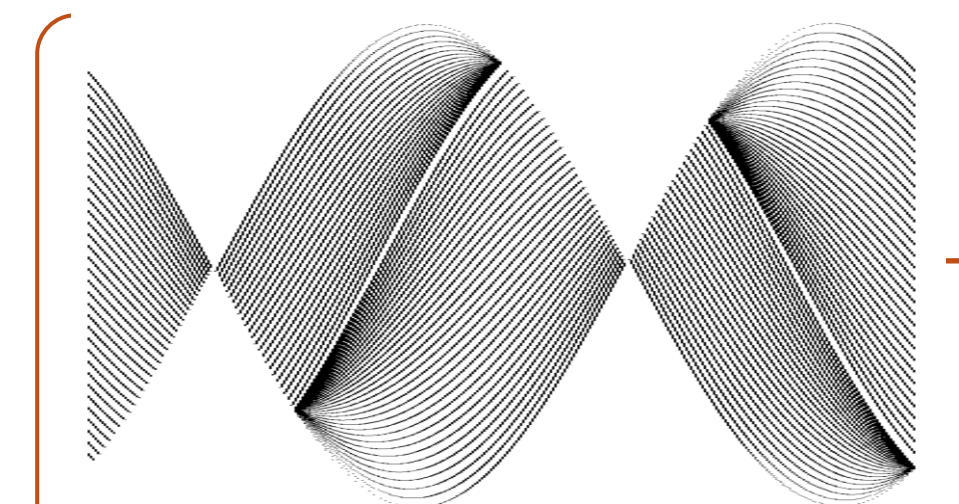


Masking
Simulate rectangular CT

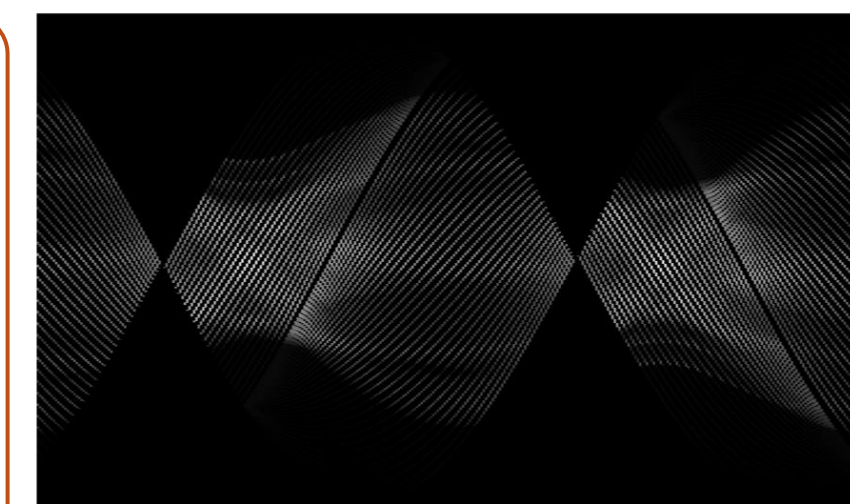


= sparse sinogram
= input data

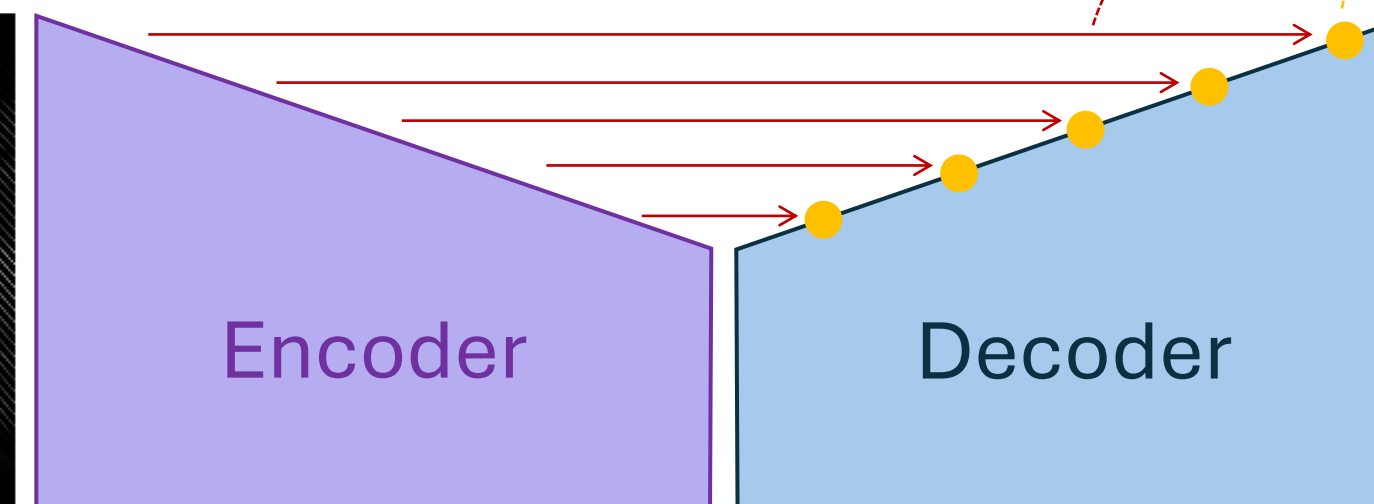
2D U-Net



Inverse mask
Indicate the regions that need to be filled (future work)

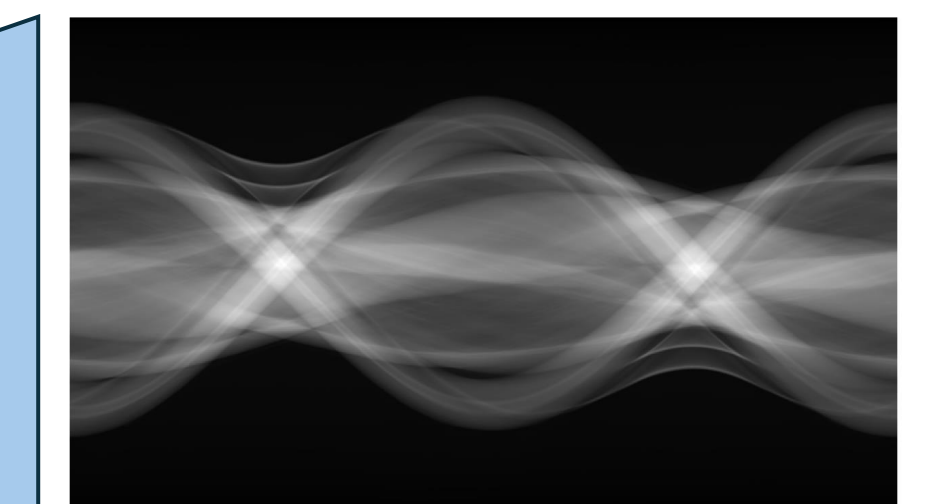


Sparse sinogram



Encoder

Decoder



Full sinogram

Tailored loss function

Sinogram-based

Sinogram
Compare the inpainted and full sinogram (RMSE, L2)

Weighted
RMSE/L2 with higher weights assigned to the inverse mask

Absorption
Compare the sum of inpainted and full sinogram across all angles (L2)

Frequency information
Compare the 2DFFT of the inpainted and full sinogram (L2)

Image-based

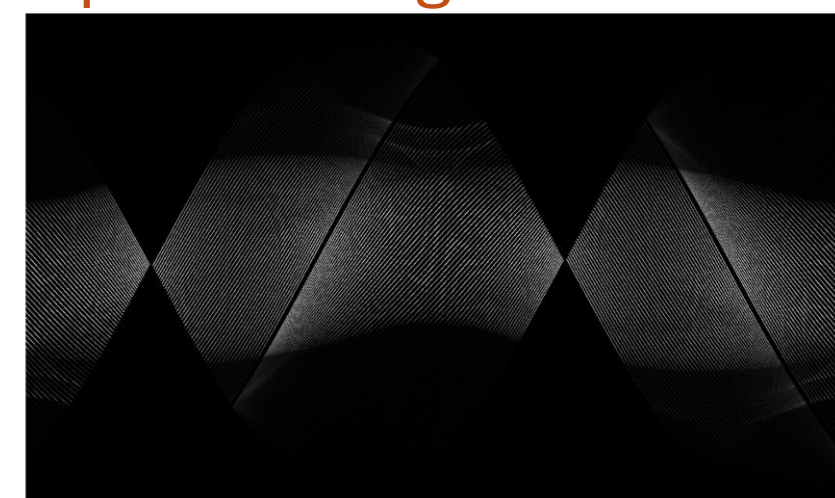
Reconstruction
Compare the reconstructed image of the inpainted and the full sinogram (RMSE, PSNR, SSIM)

Perceptual information
Compare the feature map of the reconstructed image of the inpainted and full sinogram by use of a VGG16

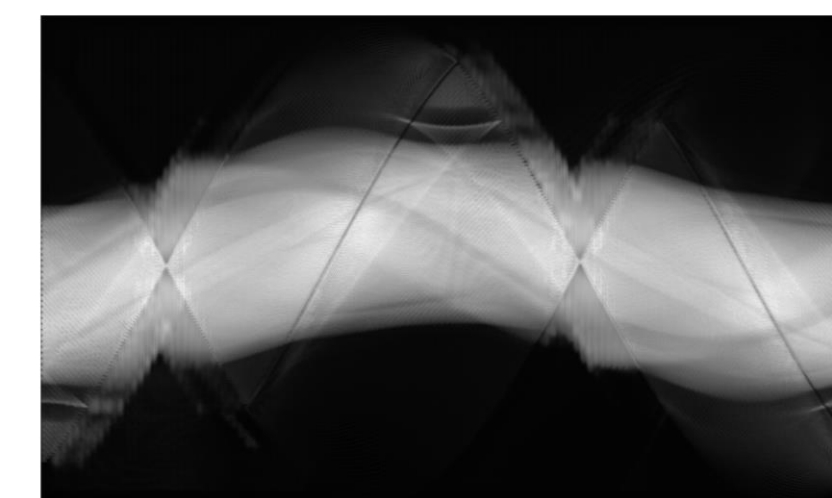
First results

- Attention gates
- Weighted RMSE loss
- 4 layers
- 200 epochs

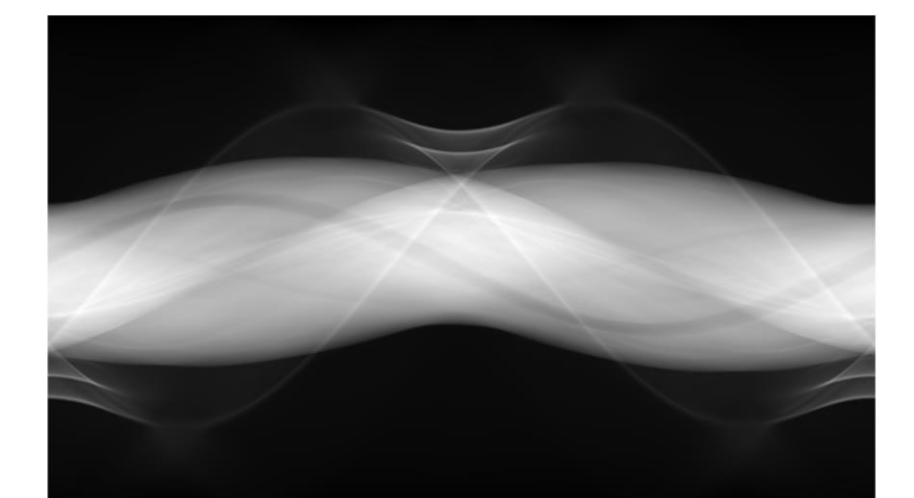
Sparse sinogram



Prediction



Ground truth



Conclusion

Results show that the approach is promising but that further improvements are needed.

Future work

- Inverse mask as an additional input channel: improve guidance
- Fourier domain in encoder: enhance feature extraction
- Ablation study on tailored loss function
- Optimize source placement: balance reconstruction performance with affordability
- Incorporating paired PET scans as extra information

References

- [1] S. Vandenberghe, et al., "Walk-through flat panel total-body pet: a patient-centered design for high throughput imaging at lower cost using doi-capable high-resolution monolithic detectors," EJNMMI, vol. 50, pp. 1-14, 07 2023
- [2] B. Vervenne, et al., "Feasibility study of a rectangular CT geometry for high throughput total-body PET-CT", ICIFXCT, 2024, pp. 272-275.
- [3] G. Yue, et al., "Generation of continuous and pulsed diagnostic imaging x-ray radiation using a carbon-nanotube-based field-emission cathode," Applied Physics Letters, vol. 81, no. 2, pp. 355-357, 2002.
- [4] Kuangyu Shi, et al., "Ultra-low Dose PET Imaging Challenge 2022". Zenodo, Mar. 16, 2022.